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DESCRIPTION OF SELECTED PHYSICAL CHARACTERISTICS OF THE NORTHEAST KAZAKHSTAN AREA: A PRELIMINARY REPORT

(CIA/RR IP-252)

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DESCRIPTION OF SELECTED PHYSICAL CHARACTERISTICS OF THE NORTHEAST KAZAKHSTAN AREA: A PRELIMINARY REPORT

I. INTRODUCTION

The following study provides a short description of the terrain, petrography, flora, soils, and mineral content of lakes for the Northeast Kazakhstan Area. The area is roughly a rectangle bounded by the parallels 45°N and 53°N and the meridians 75°E and 85°E. Included in the area are all of Semipalatinsk Oblast, most of East Kazakhstan Oblast, the eastern extremity of Karaganda Oblast, the northern portions of Alma Ata and Taldy-Kurgan Oblasts, and the southern extremities of Pavlodar Oblast and Altay Kray. A brief statement of the best available topographic map coverage is appended (see p. 35).

Physiographically the area occupies the southeastern extremity of the West Siberian Lowland, the eastern part of the Kazakh Folded Upland, the western part of the Altay Mountains, and the desert sands south of Lake Balkhash. Throughout the study, wherever the terms West Siberian Lowland, Kazakh Folded Upland, Balkhash Sands, and Altay Region are used, they refer only to those portions of the broader physiographic areas that lie within the Northeast Kazakhstan Area.

II. TERRAIN

A. West Siberian Lowland

The low-lying West Siberian Lowland is dominated by gently undulating forms of micro- and meso-relief. The area slopes gradually to the north and northeast, with elevations ranging between 100 meters to the north and 200 meters to the south. The plain is poorly drained and is crossed by only a few weakly incised rivers. On the broad and undissected interfluves are a large number of small lakes. The general appearance of the surface is dominated by these numerous lakes rather than by the rivers.

The Irtysh River roughly divides the Lowland into (1) a slightly hilly region to the south, which is part of the transition from the Kazakh Upland to the West Siberian Lowland, characterized by gently sloping low hills only a few meters in height; (2) to the north of the river, an area of low, broad, very gently sloping ridges several kilometers long, aligned chiefly in a northeast-southwest direction, with small lakes or streams in depressions between the ridges.

B. Kazakh Folded Upland

The terrain of the Kazakh Folded Upland, which lies to the south of the West Siberian Plain, ranges from mountains to low hills. At one time the upland was high mountain ranges; these have been eroded to such an extent that today the area possesses some characteristics of a peneplane. Essentially the region is very hilly, with mountain remnants rising above the general surface level.

Throughout the central portion is an almost latitudinal highland belt of separate low mountain massifs (Karkaral Hills, Tarbagatay Mountains, and Chingiz-Tau), which act as a water divide for streams flowing to Lake Balkhash, the Tengiz Depression, and the Irtysh River. The highest elevations occur in the Tarbagatay Range, where a few massifs exceed 2,000 meters and individual peaks rise even higher. Throughout the remainder of the highland belt the heights are approximately 1,200 meters. To the north, south, and east of the highland belt, the relief gradually decreases. In the north the terrain gradually merges with the West Siberian Lowland, to the east the deep Irtysh valley separates it from the higher Altay Mountains, and to the south are Lake Balkhash and the desert sands to the south of it. Beyond the central highland belt the terrain is characterized by low, rolling hills, generally of uniform elevation.

The Kazakh Folded Upland may be further subdivided into five terrain provinces: the Kalba Range, the Zaysan Basin, Tarbagatay Mountains, the Chingiz Region, and the Pribalkhash-Karkaral Region.

The northern and eastern boundary of the Kalba area is the Irtysh River, the western is the Kyzyl River, the southern the Zaysan Valley. The highest elevations and greatest amount of dissection occur in the east. Whereas elevations in the west range from approximately 500 to 750 meters, some elevations in the more rugged east exceed 1,400 meters. All of the rivers are tributaries to the Irtysh.

The Zaysan Basin is located in the extreme eastern part of the Kazakh Folded Upland. It is a wide, plain-like depression surrounded on the north, east, and south by mountains. On the west it gradually merges with the hills of the Upland. Lake Zaysan, with an elevation of 389 meters, occupies the lowest part of the basin. To the north and south of the lake, elevations increase at the rate of 2 to 6 meters per kilometer. Toward the west the increase is more gentle, averaging 1.3 meters per kilometer. To the east, along the valley of the Black Irtysh, the rate of increase is slightly less. The basin floor is almost flat, becoming rough only at the edges where it adjoins the mountains.

The Tarbagatay is a mountain range occupying the southeast corner of the Kazakh Folded Upland. It is the highest and most rugged part of the Upland, having a few peaks that exceed 3,000 meters. The range forms a divide between rivers flowing northward to Lake Zaysan and those flowing southward to Lakes Balkhash, Sasyk-kul', and Ala-kul'. Actually rivers reach these lakes only in the spring; during the rest of the year the streams disappear in the semi-desert areas at some distance from the lakes. The northern slope of the Tarbagatay range is steeper than the southern. The crest is a narrow ridge with steep slopes. The divide is so nearly level and little dissected that it serves as a caravan route throughout its entire extent.

The Chingiz Region occupies an area centered on the Chingiz-Tau Range and extends from Lake Balkhash to the West Siberian Lowland.

The highest elevations are in the east, where the range attains heights of 800 to 1,000 meters. The Chingiz-Tau is essentially a mountain plateau trending in a northwest-southeast direction, which gradually decreases in elevation to the northwest and eventually divides into a number of small, low mountain plateaus. The northern slopes of the range have a steep gradient and are strongly dissected by canyon-like valleys; the southern slopes have a much more gentle gradient. On the northeast the Chingiz plateau is marked by a sharp initial drop in elevation and then by a constantly decreasing slope that gradually merges with the West Siberian Plain. The surface of the slope is characterized by numerous low, mound-type hills of approximately the same elevation. Interspersed among the hills are long, low ridges trending in a northwest-southeast direction. Most of the ridges are asymmetrical, with short, steep northern slopes and long, gentle southern slopes. Valleys between ridges and hills are comparatively wide, but their floors are rough and are covered by hillocks and erratics. The southwest slope from the Chingiz Range toward Lake Balkhash is marked by three broad terraces.

The Pribalkhash-Karkaral Region south of the Chingiz Range is divided into (1) the Karkaral Hills, the higher, rougher mountain remnants of the north; and (2) the Pribalkhash, the lower, rather evenly sloping southern part. The Karkaral Range is strongly eroded, giving the appearance of a group of individual high, rugged hills developed on extrusive rocks against a background of low, rolling hills in the areas of sedimentary rock. Northern slopes of the rugged hills are

usually steeper than the southern; they are generally craggy and bare, whereas those to the south are talus covered and have more soil cover. Elevations gradually increase from the West Siberian Lowland to an average of roughly 670 meters in the Karkaral Hills and decrease southward to 343 meters at Lake Balkhash. Elevations of the highest peaks are slightly in excess of 1,200 meters. The south slope consists of several broad plain-like terraces descending from the Karkaral Hills to Lake Balkhash. Only a few erosion remnants rise above the general terrace levels. The slope terminates abruptly at the steep, northern coast of Lake Balkhash.

C. Balkhash Sands

The Balkhash Sands area is a a desert plain sloping gently to the north and northwest toward Lake Balkhash. In the southeastern part the Sands are essentially level; those of the western area contain a multiplicity of low hillocks and sand ridges aligned in a southwest-northeast direction. With the exception of a comparatively small northeastern corner, where moving, crescent-shaped dunes are encountered, the sands are fixed. Level alluvium, with some dunes, occupy the areas immediately adjacent to the Ili and Kara-Tal Rivers.

D. Altay Region

The Altay Region includes two types of relief: (1) to the north and northwest, rolling land transitional from lowland to mountain; and

(2) to the east and south, typical Altay plateau-like mountains of various elevations. The Altay is an old peneplane that has been broken by extensive faulting to form the present day landscape. Between the Aley and Uba rivers in the north is a lowland area that adjoins the West Siberian Lowland. Elevations may be as low as 250 meters. Southward from the Uba, hills become higher and more numerous and merge into low mountains with subdued relief. The southern and eastern parts of the Altay are the high mountain areas, where individual heights reach 3,000 meters and over. The area has true Altay topography, with plateau-like mountains. The plateaus are well dissected by deep crevasses and valleys, and a number of snow capped peaks rise above the plateau surfaces.

III. PETROGRAPHY

A. West Siberian Lowland

Having been submerged beneath the sea from very early to Quaternary times, the West Siberian Lowland is covered to great depths with horizontal sedimentary deposits that have not been disturbed by folding. Cross sections indicate that the Quaternary deposits are largely sandstones, sands, and clays. The upper strata of these deposits tend to possess the following characteristics: (1) stratified sandy clays with marl; (2) fine grained sands with interstratifications of coarse sands and conglomerates; (3) clayey strata with layers of marl and some veins of gypsum; and (4) stratified clays with a large number of marl concretions. Sandstones make their appearance in the lower strata. In the southeastern corner of the West Siberian Lowland, deposition of clays and sands are also the result of glacio-fluvial action associated with a limited advance of an ice sheet from the Altay Mountains.

B. Kazakh Folded Upland

The Kazakh Folded Upland is divided into five petrographic provinces: (1) the Ekibastuz province, situated in the northwest and centered on approximately 51°40'N, 75°20'E; (2) the Bayan-Aul province, at approximately 50°00'N, 76°00'E; (3) the Chingiz province, occupying approximately the middle of the Upland and centered at about 48°30'N, 79°00'E; (4) the Tarbagatay province in the southeastern corner of the Upland at 47°30'N, 82°00'E; and (5) the Kalba Mountain Range in the northeast at approximately 49°30'N, 83°30'E.

1. Ekibastuz Province

In the Ekibastuz province the principal rocks are effusives of Silurian age. Upper Silurian effusives, comprised of complicated depths of porphyrites and their tuffs, are found only in the southern part of the province. In the upper portion, albites and felsites become significant, along with porphyrites. Beneath the Upper Silurian is a zone of transition to Lower Silurian, which is composed of porphyritic deposits, with interstratifications of sedimentary rock. Underlying the transitional zone is a Lower Silurian stratum of conglomerates and sandstones, through which are scattered a few porphyrites. Outflows of microdiabases and porphyries of diabase and hornblende are evident in Lower Silurian formations, especially in its upper portions. Diabases, diabase porphyrites, spilites, albites, felsites, olivine basalt, and porphyrites with phenocrysts of augite, hornblende or plagioclase are among the components of effusive rocks. Orthoclase porphyries with microperthite phenocrysts are infrequently encountered. Analyses of felsitic quartz albites gives the following chemical composition by percent for effusives of the Ekibastuz region:

Mineral	Analysis Number 1	2	3	Mineral	Analysis Number 1	2	3
SiO_2	76.25	76.08	71.37	MgO	0.09	0.27	0.25
TiO_2	0.07	0.22	0.45	CaO	0.33	0.34	0.42
Al_2O_3	11.69	12.46	14.91	Na_2O	2.84	3.27	4.49
Fe_2O_3	1.88	1.75	2.70	K_2O	5.40	3.78	3.60
FeO	0.80	0.59	0.71	CO_2	0.12	0.18	....
MnO	0.02	0.01	0.02	H_2O	0.54	1.09	0.99

As a result of folding, the effusives contain a multiplicity of intrusions in the form of stocks and small bodies of granite porphyries, alkaline granites, granodiorites, syenites, diorites, and gabbros. In the southern part of the area, most of these intrusions occur as stocks. Stocks of arfvedsonite-anorthoclase granite porphyries are present in the Shakshan vicinity (51°10'N, 76°00'E). At contact zones these rocks are characterized by the presence of actinolite, epidote, and albite gravels. The chemical composition of the arfvedsonite-anorthoclase granite porphyry by percent is as follows:

Mineral	Percent	Mineral	Percent	Mineral	Percent
SiO_2	74.97	FeO	0.98	Na_2O	3.96
TiO_2	0.32	MnO	0.05	K_2O	4.42
Al_2O_3	12.11	MgO	0.25	H_2O	0.48
Fe_2O_3	2.03	CaO	0.32		

Diorite porphyries form rather extensive laccolithic intrusions at two areas -- approximately 51°30'N, 75°50'E and 51°50'N, 75°40'E. These porphyries have phenocrysts of strongly sericitized plagioclase embedded in a fine grained groundmass. Hornblende is almost totally absent. Laccoliths in the vicinity of Lake Uch-Kul' (51°30'N, 75°50'E) have albite porphyries, plagioclase porphyries, and felsites in a close association with intrusive diabases, gabbros, and spessartite. To the north of the Uch-Kul' laccoliths lies a long (67 km.), narrow belt of serpentines exhibiting strong metamorphic features. These serpentines form the core of two large massifs. These massifs contain

gabbros, diorite porphyries, garnets, pyroxene, vesuvian, and actinolite along with serpentines.

2. Bayan-Aul Province

In the Bayan-Aul province, the rocks are chiefly of Paleozoic age although some are Mesozoic and Cenozoic. The dominant formations are Silurian to the east and Devonian and Carboniferous to the west. Granitic magmas were intruded into the Paleozoic formations, chiefly in the area to the right of the Chedermy River in the eastern part of the province.

Silurian formations are made up principally of the three following strata: (1) Upper Silurian sandstone; (2) Upper Silurian porphyrites and tuffs; and (3) Lower Silurian ancient porphyritic lavas, tuffs, sands, agglomerates, and limestones. The Devonian consists of sands, conglomerates, and marl overlying limestones. Clay and sand deposits, with traces of coal, comprise the Carboniferous formations.

Graywacke, with fragmentary porphyritic materials, is the principal constituent of Upper Silurian. Underlying the graywacke is a formation of plagioclase porphyrite, agglomerates and sands, dark colored lavas, tuff-breccias, and conglomerates. The porphyrites have phenocrysts of plagioclase, sometimes accompanied by pyroxene or olivine. Vulcanic tuffs, which are widely distributed, contain glass, plagioclase, pyroxene, chlorite, epidote, limonite, quartz, and chalcedony.

The Lower Silurian porphyrite formation is extremely varied in character. Among its constituents are spilites, spherical lavas, and lava breccias. The spilites are made up of albite-oligoclase, augite,

and strongly chloritized glass. Labradorite and andesite are present in phenocrysts. The groundmass contains much albite. Hematite, magnetite, and ilmenite are widely diffused throughout the formation, and calcite, prenite, chlorite, epidote, and augite are also present. Lavas are highly crystallized and contain plagioclase, ophyte, and albite, with some augite accompanied by olivine. Scattered throughout are amygdules of calcite, prenite, epidote, zeolite, chlorite, actinolite, chalcedony, and quartz. Strata of siliceous schists and various colored jaspars are sometimes interbedded in Lower Silurian formations.

Intrusions of Silurian age in the form of gabbros, pyroxenes, peridotites, and granodiorites break through both Upper and Lower Silurian formations. Granosyenite intrusions are found in the northern part of the province in the Tolpak Mountains. The granosyenite is characterized by the presence of the following: orthoclase-perthite 41 percent; plagioclase 29 percent; quartz 17 percent; biotite 5 percent; hornblende 1 percent; apatite 1 percent; and ore minerals 6 percent. Constituents of the peridotites are olivine, bronzitite, titanite, magnetite, chlorite, and diallagite.

Devonian deposits of the Bayan-Aul province are chiefly lavas, with their tuffs, and sedimentary tuffites with conglomerates. The effusives are essentially of the three following types, depending upon the type of phenocrysts present: (1) quartz-perthite, (2) perthite, and (3) albite. Oligoclase, andesite, albite, perthite, quartz, anorthoclase, and hornblende porphyries have also been identified.

Post Carboniferous intrusions produced laccoliths, stocks, and dikes of granites, syenites, monzonites, and syenite porphyries. Outcrops of granite occupy 18 percent of the Bayan-Aul area and are concentrated in two belts -- one to the south extending for 200 kilometers and the other to the northeast.

Various forms of red granites are dominant in the southern belt. Dikes of lamprophyres, aplite, and pegmatite are numerous. At contacts the granites are altered to syenites, monzonites, granodiorites, and quartz diorites. Analyses of red granites give the following results: quartz 30-33 percent, perthite 45 percent, oligoclase 20 percent, and biotite or hornblende 2-4 percent.

Intrusions of the northern belt are principally gray granites. Analyses of northern granites at Kyzyl show their approximate compositions to be as follows: oligoclase 10-20 percent, perthite 50-55 percent, and quartz 25-30 percent. Granites near Bayan-Aul have the following composition: quartz 18 percent, microcline-perthite 48 percent, oligoclase 31 percent, and biotite 2 percent. Granodiorites in the same vicinity are composed of: quartz 21 percent, plagioclase 50-55 percent and microperthite 10-15 percent. At contacts of intrusions, sandstones tend to be altered toward quartz and limestones toward marble. There is also an associated development of hedenbergite, diopside, garnet, epidote, chlorite, and hornblende.

3. Chingiz Province

The Chingiz province is blanketed with Paleozoic effusives ranging from Cambrian age through Carboniferous. All of the Paleozoic

deposits have roughly the same metamorphic character and possess a phyllitic rather than a typical schistose nature. Cambrian phyllites contain interstratifications of porphyrites and porphyries that have been affected by metamorphic processes to such a degree as to make them difficult to distinguish from sedimentary phyllites. The effusive porphyritic interstratifications of Silurian, Devonian, and Carboniferous are much less metamorphosed than those of Cambrian age. Quartz, albite, and orthoclase porphyries are most commonly encountered in the area. The most common phenocrysts embedded in quartz porphyries are quartz, orthoclase, and plagioclase. Porphyrites contain phenocrysts of oligoclase, andesine, and hornblende embedded in a pilitic or hyalopilitic groundmass.

4. Tarbagatay Province

The Tarbagatay province is overlain principally with Middle Devonian and Lower Carboniferous deposits. Middle Devonian deposits are metamorphosed green and red clay-schists and phyllites. Many outcrops of granite, principally the biotite variety, break through the deposits. At the extremities of granite outcrops, diorites and syenites are found. Effusive rocks are represented also by quartz porphyries and their tuffs, diabase, porphyrites, and melaphyres. Since analyses of Tarbagatay rocks are unavailable, the chemical composition of similar rocks of the adjoining Dzhungarian Ala Tau are given (in percent of total composition).

Minerals	Analysis Number 1	2	3	4	5	6	7	8
SiO_2	69.83	68.68	68.70	48.61	64.51	60.71	52.02	62.82
TiO_2	0.54	0.55	0.40	1.22	....	....	1.05	0.60
Al_2O_3	16.63	17.69	16.24	20.84	17.55	20.30	19.03	18.33
Fe_2O_3	....	....	2.72	....	3.28	2.24	5.73	2.34
FeO	3.67	2.61	0.21	7.42	1.46	2.59	3.40	0.66
MgO	1.78	1.40	2.04	7.42	2.24	1.73	3.08	1.11
CaO	1.90	2.10	2.33	8.86	4.60	3.08	8.60	7.09
Na_2O	3.40	4.13	1.84	3.05	2.05	5.78	3.19	2.64
K_2O	1.70	3.45	4.48	0.64	2.45	2.73	1.12	3.02
H_2O	0.89	0.59	1.86	1.94	1.76	1.31	2.33	0.61

5. Kalba Province

The Kalba region as a whole is lithologically dominated by strongly metamorphosed Lower Carboniferous schists and sandstones with occasional lenses of limestone and in some places interstratifications of coal and limestone. In the southern part of the Kalba province, there are tuffaceous sandy deposits with interstratification of jaspar. In the northwestern part of the Kalba mountains, Devonian clay schists, tuffites, and jaspar are found. Alkaline granitic intrusions, accompanied by veinstones, are widely distributed throughout the province. These intrusions, have gneiss-like characteristics, with the tendency of plagioclase to be united with quartz and potash feldspar. In the southern part of the Kalba Range granodiorite intrusions form small massifs, with which olivine, gold, and wolframite are associated.

Magmatic activity produced a large number of aplite, pegmatite, and quartzite dikes. Tin is associated with quartzite dikes.

Kalba granites are usually coarse grained and alkaline. They consist of quartz, microcline, plagioclase, biotite, muscovite, zircon, apatite, sericite, epidote, chlorite, and limonite. The average granite has about 31-39 percent microcline and 27-31 percent plagioclase; the biotite and muscovite content is negligible. Medium grained granites, in addition to the above composition, also contain titanite, magnetite, and sagenite. The granodiorites are usually composed of quartz 24-33 percent, microcline 0.8 - 0.9 percent, plagioclase 53-56 percent, and biotite 10-21 percent, with muscovite, zircon, and apatite, among the secondary minerals. In the granodiorite massifs of the southern part of the Kalba province the rock composition is quartz 15 percent, microcline 9 percent, plagioclase 66 percent, biotite 8 percent, and epidote 2 percent.

In contact zones there are developments of veiny aplites, diorite-porphyrites, quartz-diorite porphyries, granite porphyries, and pegmatites. Pegmatite dikes or veins contain aplite, a large amount of feldspar and quartz, muscovite, tourmaline; sometimes topaz, scheelite, augite, and beryl are present. At granite contacts in some areas, there are breccias made up of quartz, plagioclase, a large amount of biotite, epidote, and zircon. At the extremities of granitic intrusions, there are formations of plagioclase-microcline schists, chlorite-tourmaline schists with metacrysts of chlorite, tourmaline-mica schists, mica-andalusite schists, and biotite schists.

Chemical analyses of granitic rock of the Kalba province in percent of total rock composition gave the following results:

Mineral	Analysis Number 1	2	3	Mineral	Analysis Number 1	2	3
SiO_2	73.03	71.25	65.86	CaO	0.77	1.14	3.09
TiO_2	.....	0.35	0.60	Na_2O	4.04	2.62	3.97
Al_2O_3	13.31	14.59	15.30	K_2O	6.12	4.86	3.47
Fe_2O_3	1.57	1.35	2.76	H_2O	0.46	1.12	1.20
FeO	0.94	1.15	1.95	P_2O_5	....	0.41	0.19
MnO	....	....	0.09	S	0.27	0.34	0.35
MgO	....	0.59	1.34				

C. Balkhash Sands

The Balkhash Sands is an enclosed basin with post Tertiary fluvio-glacial and alluvial lake sand deposits, 75 percent of which is covered by aeolian sands. The sands are well rolled, small (sometimes pulverized) grains of quartz. Quartz grains are usually covered with a thin film of hydrates and iron oxides. In addition to quartz, grains of hornblende, augite, magnetite, mica, and feldspar are fairly abundant.

D. Altay Region

The rock cover in the Altay Region consists mainly of metamorphosed Devonian and Carboniferous strata. In the northeast there is a very small area of Cambrian and Silurian in the form of schists, sandstones, tuffs, and limestone. At the termination of the Paleozoic era the area

experienced intense folding and, as a consequence, many intrusions of granitic-type rocks. Polymetallic ores, gold, wolfram, and tin are associated with these intrusions.

The mountain stretch to the right of the Irtysh River has been described as containing the following rocks: (1) stratified veins of granulites containing quartz, albite, orthoclase, microcline, and orthoclase with admixture of almandite, as well as some tourmaline, magnetite, pyrite, and quartz-tourmaline veins; (2) mica schists; (3) twin mica granite schists; (4) granite-staurolite schists; (5) disthene-granite schists composed of disthene, biotite, and granite with admixture of quartz; (6) mica gneiss; (7) biotite gneiss of porphyroblastic granite; (8) muscovite gneiss with strongly sericitized plagioclase; (9) twin mica gneiss; (10) hornblende gneiss; and (11) amphibolite and hornblende schists.

At contact zones of these rocks the following developments are in evidence: (1) strata of pyroxene gneiss developed from sedimentary rock, which occur along the River Ul'be and include among the constituents diopside, plagioclase quartz, and calcite; (2) strata of biotite gneiss containing biotite, oligoclase, and andesine; and (3) among pyroxene gneisses of the Ul'be area, interstratifications of scapolite-diopside schists, which are fine grained rocks composed of quartz 20-40 percent, scapolite 30-40 percent, and diopside 30-40 percent, with an admixture of titanite.

There is also a distribution of (1) clastic gneiss of albite and quartz with an admixture of titanite, chlorite, epidote, and pyrite;

(2) epidosite with bands of quartz and epidote, which occurs in the northern outskirts only; (3) strata of chlorite schists with seams of quartz and crystals of pyrite; chlorite comprises 75 percent of the rock. Metamorphism also produced quartz-sericite schists and sericite talc.

Extrusive rocks of the Altay Region include: (1) quartz-albite porphyries with phenocrysts of quartz and feldspar embedded in a felsitic groundmass, with scales of sericite found on the surfaces of schistosity; (2) felsitic albite porphyries containing considerable amounts of sericite and occasionally chlorite, epidote, and actinolite; (3) felsites whose groundmass is composed of quartz and feldspar; and occasionally (4) fine grained epidote porphyries with phenocrysts of albite plagioclase and a groundmass of quartz, albite, and feldspar.

Widely distributed in the Zyryanskoye area (49°40'N, 84°20'E) are granitic rocks characterized by an almost negligible amount of schistosity. Near contacts the granites acquire a porphyritic structure and contain considerable epidote. Amphibolites are also present.

IV. FLORA

The pattern of vegetation in the Northeast Kazakhstan Area corresponds closely to the physical regions. The vegetation of the West Siberian Lowland is largely steppe. The Lake Balkhash area is semi-desert and desert. On the hilly and mountainous slopes of the Kazakh Folded Upland and the Altay Mountains the vegetation is a complex mixture that varies with the elevation.

A. West Siberian Lowland

Except for the belts of trees on the higher portions of the mountain slopes, forest vegetation is to be found only in the Ob' River area in the northeastern corner of the West Siberian Lowland. Even here, trees occupy only a small part of the total area, which is predominantly grassland. Small groves of trees, composed chiefly of pine and birch, give the landscape a characteristically parkland appearance.

The groves of trees become increasingly rarer to the south, and the mixed forest-grassland zone merges into the steppe zone. In the true steppe, grass completely dominates the vegetation cover. The number of species represented in the steppe zone is considerable, being somewhat higher in the north, and gradually declining to the south.

Various types of feather grass predominate on the belt of chernozem soils southeast of the city of Slavgorod, in the northern part of this steppe zone. In this northern belt, maidenhair, steppe oat, and fescue are generally associated with the feather grasses. Steppe alfalfa and

astragalus (Astragalus macropus) are the two most characteristic leguminous plants.[1] Other typical representatives of the natural vegetation are cinquefoil (Potentilla), wild thyme (Thymus serpyllum), veronica (Veronica officinalis), and a series of Siberian forms of wormwood (Artemisia glauca, A. latifolia, etc.). Most of the northern belt is at present under cultivation, with grains, especially wheat, being the principal crops. Grazing and hay production are also significant wherever soil-moisture conditions are favorable, as along the shores of the few fresh water lakes. As a result of excessive grazing in some localities, the original grass cover has been supplanted by wormwood.

In the southern part of the steppe zone, along the banks of the Irtysh River in the Pavlodar-Semipalatinsk area, the principal components of the vegetation cover are feather grass and fescue. The decreasing quantity of moisture available for the vegetation here is reflected both by the dominance of the more xerophytic forms, and by the sharp reduction in the area of sod cover (40-60 percent of the surface). Between the patches of feather grass and fescue (generally intermixed with maidenhair and koeleria) are onions and several species of wormwood. Along the banks of the salt lakes and in the depressions where the ground-water table approaches close to the surface, solonchak soils support halophytic vegetation such as glasswort (Salicornia herbacea) and Halocnemum strobilaceum. The floodplain of the Irtysh River, with its cover of meadow grass, beds of reeds, and groups of shrubs along the

1. In citing species, both the common and Latin designation have been used where possible. In some instances, however, only the common generic term or the Latin designation was available.

banks, forms a vivid contrast with the characteristic steppe vegetation cover of the area. During the spring, when the moisture of the soil is at its maximum, quick-growing mesophytic perennials and annuals may become established. In the southern steppe zone the natural vegetation is preserved over considerably larger areas than in the north, since agriculture is limited to flood plains and the other small areas where soil moisture conditions are favorable.

B. Kazakh Folded Upland

To the south of the steppe zone is the Kazakh Upland extending from Karkaralinsk eastward. Here difference in elevation is the controlling factor in the distribution of vegetation. The highest sections of the slopes support considerable pine forest. In the mountain valleys and the intervediate upland areas, birches, aspen, pyrola (Pyrola rotundifolia), and Monesis grandiflora are the dominant types of vegetation. Even such northern forest and marsh forms as eriophorium (Eriophorium polyctachium), Lupula campestris, lathyrus (Lathyrus palustris), Lysimachia vulgaris, carex (Carex caespitosa), and Fragaria vesca grow in these high mountain valleys.

The somewhat lower elevations are dominated by steppe vegetation, in which feather grass, fescue, koeleria (Koeleria gracilis), desert oat (Avena desertorum), and crested wheat grass (Agropyrum cristatum) constitute the principal types. Species of secondary importance include Onosma simplicissimum, scabious (Scabiosa isetensis), gypsophila

(Gypsophila gmelini), aster (Aster alpinus), Centaurea sibirica, and Statice speciosa.

The low-lying, level southern part of the Kazakh Upland supports only a poor wormwood-grassy semidesert vegetation. Among the principal species represented are capillary feather grass (Stipa capillata), Lessing's feather grass (Stipa Lessingiana), steppe fescue (Festuca sulcata), koeleria (Koeleria gracilis), Ferula tatarica, wormwood (Artemisia frigida, A. campestus).

C. Balkhash Region

The area immediately adjoining Lake Balkhash is generally classified as desert. North of the lake the sparse vegetation cover is dominated by wormwood and halophytes. On the small patches of sandy soils the solonchak sauxaul (Haloxylon aphyllum), and possibly Populus diversifolia and Calligonum aphyllum, may be found. The area to the south of Lake Balkhash is largely a sandy desert. Sandy ridges, extending to heights of 5-10 meters, are the dominant relief features. On the top of these ridges the vegation cover is limited to psammophytic shrubs -- calligonum (Calligonum aphyllum, C. leucocladum), white or sand sauxaul (Haloxylon persicum), and some pinnate aristida (Aristida pennata). On the slopes of the ridges the vegetation cover increases slightly. The characteristic species include the "Dzhungarian or green wormwood" (Artemisia songorica), ephedra (Ephedra lomatolepis), Eurota ceratoides, Agropyrum sibirica, Salsola pellucida. Vegetation is somewhat denser in the depressions between the ridges and on the level sandy areas. Here the solonchak

saxaul is a dominant species, together with white wormwood (Artemisia terrae albae), sedge (Carex physodes), Kochia prostrata, and ephemerons. Near settlements the vegetation cover has been altered somewhat, and the sandy ridges are no longer well stabilized. The sands tend to migrate, and distinct crescent dunes begin to appear. On this moving sand, vegetation is either absent or limited to such pioneers as pinnate aristida (Aristida pennata) and Chondrilla ambigua.

D. Altay Region

The complex vegetation pattern of the mountainous eastern zone is intimately associated with vertical differences in elevation. The principal vegetation types are: (1) almost bare tundra on the high mountain slopes, (2) coniferous forests on the intermediate portions of the slopes, (3) grass steppe, and finally (4) semi-desert. In the Altay, for example, the highest peaks lie above the upper limit of trees, and the vegetation is limited to mosses or lichens, with occasional dwarf birches. The upper boundary of forest vegetation ranges between 1,950 and 2,400 meters, with the higher elevations being typical of the southern and eastern Altay. In the southern Altay, the forest belt extends down to 1,000 meters and in the west to 350 meters. The vertical distribution of these zones is complicated locally by activities of man and by differences in exposure. Because of the more intensive action of the sun's rays, the south-facing slopes are drier. As a result, the south-facing slopes of a given valley may be devoid of trees, while the opposite slope is densely forested. Continuous

cuttings and fires have denuded other areas of the original cover of coniferous forest, predominantly Siberian larch (Larix sibirica) and Siberian pine (Pinus sibirica). On the higher portions of the slope, birch and aspen may replace the original forest cover. Farther down the slope, such a disturbed forest cover is generally succeded by a grass cover which provides additional meadow and pasture areas. This mountainous meadow landscape has become a characteristic feature of the Altay. The flora of the lower-lying portions of the mountain slopes is similar to that of the steppe and semi-desert zones described.

V. SOILS

A. West Siberian Lowland

The pattern of soil distribution within the Northeast Kazakhstan Area coincides fairly closely with that of vegetation. On the West Siberian Lowland, chernozem soils predominate in the northeast. Their humus content is high, measuring about 5-10 percent of the upper soil horizon. The thickness of the humus layer is about 35-70 centimeters. The zone of carbonate accumulation may reach a thickness of 60-70 centimeters. On the drier southern and western margins of the Lowland, chesnut soils are well developed. The humus layer of these chesnut soils reaches a maximum thickness of 50 centimeters. Their humus content is somewhat lower than that of the true chernozems, amounting to about 4-7 percent. Another characteristic of the chesnut soils is the large content of calcium near the surface. In the depressions within the West Siberian Lowland, the characteristic soils are solonets solonchak, both of which have a high salt content. The texture of the West Siberian Lowland soils varies considerably, for the alluvial parent material ranges from clays to sands.

B. Kazakh Folded Upland

The soils on the Kazakh Upland are somewhat coarser in texture than those of the Lowland. They are generally shallow and contain a high proportion of stones, and outcrops of bare rock are numerous throughout the area. Although the Upland soils are not as well developed as those

in the southern part of the West Siberian Lowland, they are generally classified as chesnut soils.

C. Balkhash Region

Immediately north of Lake Balkhash are the brown and sierozem soils that are characteristically developed under desert conditions. The humus content of these soils is low, the maximum being 1-2 percent. The zone of carbonate accumulation lies at a high level and may even reach the surface.

South of Lake Balkhash, sands predominate. The sands, being little changed by soil-forming processes, remain an infertile parent material without a developed soil profile. In some parts of this area the patches of salt pan and solonchak may cover as much as 30 percent of the surface. A primitive grey alkaline soil in the southwestern corner of the Balkhash Region, is the only example of true soil development in the Region.

D. Eastern Mountains

The distribution of soils in the mountainous eastern part of the Northeast Kazakhstan Area is similar to the distribution of vegetation and, like it, has a zonal pattern that varies with the elevation. This pattern is well illustrated by the soil zonation in the Dzhungarian Ala-Tau. The lowest portions of the slopes have sierozem soils, solonchaks, and desert sands. Between 600 and 800 meters, chesnut soils appear. The chernozem develops at elevations ranging from 800 to

1,200 meters. Above 1,200 meters the soils under the cover of forest and mountain meadow are slightly podzolic. Above the zone of forest vegetation, are poorly developed soils, with numerous rock outcrops on the high mountain slopes. The sequence of zones in the Altay is similar, except for the omission of the desert sierozems, sands, and solonchaks.

VII. LAKES

A. West Siberian Lowland

The poorly drained West Siberian Lowland contains a large number of small, shallow lakes. In some areas the lakes are scattered singly over the surface; in other localities they tend to occur in groups. Some are fresh or nearly so, whereas in other the concentration of salts is so strong that part of the salt is precipitated out every year during the period of high evaporation. Saline and fresh-water lakes may occur side by side. Sodium chloride is common to all the saline lakes, but the carbonate and sulphate content may reach considerable proportions. Chemical analyses of various lakes in the West Siberian Lealand are given in Table 1.

B. Kazakh Folded Upland

The lakes of the Kazakh Upland also are generally small and shallow, and the great majority are strongly saline. Scattered among the numerous saline lakes, however, are a number of fresh water or only slightly saline lakes. Chemical analyses available for lakes in the Kazakh Upland are given in Table 2.

Since the analysis for Lake Bol'shoy Kalkaman is given on the basis of salt content instead of ions, it could not be incorporated into the table. The analysis is therefore given separately (see page 33).

Table 1. Analyses of Lakes of the West Siberian Lowland

Lake	Composition in Gram Ions per Liter: Chloride (-)	Sulphate (-)	Carbonate (-)	Bicarbonate (-)	Sodium (+)	Magnesium (++)	Calcium (++)	Density (Baume)	pH
Bol'shoye Pelukhovskoye	3.83	1.08	7.13	1.16	8.90	.....	.....	1.7°	....
Bol'shoye Varovoye	114.95	6.68	0.43	6.53	54.28	13.04	0.74	.....	....
Gor'koye[1]	4.97	1.08	1.86	1.96	5.93	.....	.....	.....	10.1
Gornostayevo	132.70	59.20	.....	0.135	95.90	10.01	.....	.....	....
Kucherpak	41.81	9.33	73.78	22.15	96.56	.....	.....	27.5°	....
Kuchuk[1]	71.14	31.63	.....	0.67	47.80	7.23	0.049	.....	....
Kuludinskoye	141.10	26.20	.....	.....	91.40	6.75	.....	.....	....
Mal'iye Petukhovskoye	35.13	1.42	42.40	16.26	62.07	.....	.....	17.4°	....
Mal'iye Petukhovskoye A	7.83	1.94	15.90	6.53	20.60	.....	.....	6.2°	....
Peresheyechnoye[1]	4.18	0.74	1.47	2.47	5.14	.....	.....	.....	10.2
Srostinskoye[1]	1.61	0.34	0.33	1.89	2.12	.....	.....	.....	....
Tanatar I	12.56	3.65	17.15	2.54	24.00	.....	.....	7.0°	....
Tanatar II	8.31	1.69	12.11	1.67	16.17	.....	.....	5.0°	....

1. Composition given in gram ions per kilogram.

Lake	Composition in Gram Ions per Liter							Density (Baume)	pH
	Chloride (-)	Sulphate (-)	Carbonate (-)	Bicarbonate (-)	Sodium (+)	Magnesium (++)	Calcium (++)		
Tanatar III	7.71	2.43	10.07	2.54	14.89	.....	.....	5.0°	....
Tanatar IV	3.15	1.01	4.02	1.45	6.17	.....	.....	2.0°	....

Table 2. Analyses of Lakes in the Kazakh Folded Upland

Lake	Composition in Gram Ions per Liter								Solid Material (grams)	Specific Gravity	Loss upon Calcination (grams)
	Chloride (-)	Sulphate (-)	Carbonate (-)	Bicarbonate (-)	Sodium (+)	Magnesium (++)	Potassium (+)	Calcium (++)			
Al'gren Sor	5.14	12.63	.....	.....	2.247	1.030	0.942	2.287	.....	1.017	0.636
Altybay-Sor	177.38	67.56	.....	.....	102.70	22.34	2.36	.....	371.46	1.243	3.231
Ekibas-Tuz	196.30	5.343	9.314	13.51	95.93	.....	10.38	5.084	335.8	1.206	3.763
Kemmer-Tuz[1] (Kemper-Tuz, Temir-Tuz)	163.90	39.79	.....	.....	94.30	10.87	.....	2.426	.....	.....	.....

1. Density -- 26.5 Baume at 26°C.

Lake Bol'shoy Kalkaman

Composition in grams per kilogram

Sodium chloride	184.91
Magnesium chloride	108.68
Calcium sulphate	1.34
Magnesium sulphate	18.19
All solid materials:	354.83 grams per liter
Specific gravity:	1.24

C. Altay Region

The lakes in the Altay area are few in number, small in size, and are located principally in the river basins. Although detailed chemical analyses are meager or almost entirely lacking, the mineral content of the Altay lakes is probably considerabely lower than that of the lakes in other parts of the Northeast Kazakhstan Area. The following facts support this inference: (1) drainage is over ancient crystalline and metamorphic rocks, (2) the rate of flow is high, (3) the water changes rapidly, and (4) the rate of evaporation is low.

D. Lake Balkhash

Lake Balkhash, the largest lake within the Northeast Kazakhstan Area, has a length of over 600 kilometers and is fairly shallow. In the western part the average depth is slightly less than 5 meters. In the east the depth is somewhat greater, ranging between 5.5 and 12.3 meters on the average. The chemical composition of the water

varies considerably from place to place and from season to season. The eastern part is saline, whereas most of the western part is fresh. The difference in composition is attributable to the tremendous quantities of fresh water contributed by the Ili River in the west. In July the salinity of the water is at a minimum, principally because of the seasonally greater volume of water provided by the Ili. After July the effect of the high rate of evaporation makes itself felt, and the salinity gradually increases until it reaches a maximum in the period from January to March. Detailed chemical analyses of the saline eastern part are not available, but sulphate and chloride salts predominate.

TOPOGRAPHIC COVERAGE

There is no uniform large-scale topographic coverage available for the study area. The Russian 1:500,000 series published in 1939 by the Principal Administration for Geodesy and Cartography (Glavnoye Upravleniye Geodezii i Kartografii pri SNK SSSR) is the largest-scale series available that includes a considerable portion of the Northeast Kazakhstan Area. Even at 1:500,000 complete coverage is not available. For areas for which sheets of the 1:500,000 series are not available, the Army Map Service 1:1,000,000 series (1950) should be used. Reproductions of the available sheets of the Russian 1:500,000 series and originals of the required sheets of the AMS 1:1,000,000 series are provided with the study.

Topographic Coverage Diagram for Accompanying Maps

LIST OF MAPS

/1:500,000 Series of the Eastern Kazakhstan Area/; 1:500,000; Glavnoye Upravleniye Gosudarstvennoy S"emki i Kartografii NKVD-SSSR; Omsk, 1938.

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